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Atoms for Peace Celebration

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The conditions for nuclear energy to supply an adequate share in the future world energy mix

According to most experts, under the combined pressure of the demographic growth and the need for a more equitable development of Third World countries, demand for energy is going to double at least in the next 50 years, despite strenuous efforts to increase energy efficiency. And this increase of demand must be met while reducing the release in the atmosphere of Greenhouse Gases (GHG), the main source of which being the combustion of fossil fuels, which today account for 80% of our consumption. This challenge cannot be met without increasing in our energy mix the share of non GHG-emitting sources, renewables and nuclear power.

Today, nuclear power supplies slightly more than 6% of the world energy consumption, which is equivalent to the oil production of the largest oil supplier, be it Saudi Arabia or the Russian Federation. If we want nuclear power to play a significant role in solving the GHG problem, it must not only follow the growth in energy consumption, it must increase its share of this growing demand. To be precise, it must at least maintain its share in Europe and the Pacific OECD, increase its share in North America, and reach a significant level in a handful of large emerging economies like China, India, Brazil and a few others. In a few decades, we can expect that nuclear energy will have other uses than electricity : water desalination, and hydrogen for direct use and synfuels production. We are speaking about 1000 to 3000 large nuclear plants, to be compared to less than 450 today.

This may look like large numbers, but if we settle for 2000 GWe, it would mean that only 2 out of 9 billion human beings would enjoy the same amount of nuclear power per capita as the French do nowadays. Hardly an ambitious target for 50 years !

Still, a world with 2000+ nuclear power plants may require some prerequisites, prerequisites for the nuclear systems and prerequisites for societies and their organisation.

"Hardware"

Let us go quickly over the prerequisites on the "hardware" side, which were extensively discussed both within INPRO and the Generation IV International Forum :

- Economy first. Future NPPs must be competitive with the best fossil fired plants. With any fair valuation of the carbon credit, this should be easy.
- Sustainability, which comprises safety, natural resources optimisation and waste minimisation.
- Non-proliferation – though most of it belongs to the "software" domain.

Proliferation is essentially a matter of political will, not technology. It is difficult to determine exactly how "proliferating" a technology is. Can an existing facility be put to illegal use or secretly copied? Are we concerned with the manufacture of a single "home-made" device or with weapon stockpiling?. Different factors must be taken into account: ease of access to the pure concentrated fissile material, detectability, throughput, etc. We can nevertheless hazard two opinions: for a few "devices", isotope enrichment is certainly the most discreet method, while for a significant arsenal, a reactor fed with natural uranium, with online fuel unloading is the most effective method.

Only natural resources optimisation and radwaste minimisation are fully dependant upon technical innovation. They both imply recycling fissile and fertile materials, which ultimately means fast neutron reactors of some kind for the uranium-plutonium cycle, and probably epithermal neutron reactors using thorium and ^{233}U. I am quite confident that, in the time frame under consideration, several HLW repositories will be in operation in the main "nuclear" countries : this is a problem for today, not for to-morrow. But these repositories will be national treasures, to be used sparingly, and that constitutes the case for including waste minimisation as a specification for future nuclear systems. I am not a firm believer in specific incinerators, second strata, and other ADS : the main nuclear systems should be able to deal with this problem "inherently".

Which points to another prerequisite, which is a lively international R&D, in support and anticipation of future industrial projects. Without R&D, without the scientific and technical manpower and the dedicated facilities – especially "hot" facilities which are very expensive to build, run and maintain, there will not be the needed technical innovations. Because it is a proof of belief in the future, R&D is also a way to attract young talents to nuclear power. In that respect, I welcome the Generation IV initiative.

"Software"

At present, the main limitation to the spread of nuclear power is probably access to capitals, in the wake of the vast "restructuring" (I was told not to use the words "deregulation" or "liberalisation" any longer) of the electricity markets throughout the western world. Even though the busbar kWh cost can be quite competitive –it is in France – nuclear power remains very capital intensive. In a pure merchant economy, any investment whose return exceeds 10 years does not appeal to the Shareholders, even though as individuals the same shareholders buy their houses with 25 years loans. This problem is not limited to nuclear plants, it concerns all the heavy infrastructure investments without which countries would not develop : gas pipes, highways, railways, high tension lines, etc. My own belief is that, where infrastructure are concerned, there is a role for the States, beyond regulation.

Both economy and safety require innovative solutions for international organisation pertaining to market, industry structure, safeguards, etc. And such solutions have already been devised and implemented within the air travel industry. There are no reason why we cannot do the same in the nuclear industry.

The air travel industry is a worthy comparison, because it is considered by the public at large as safe, despite numerous accidents in its early days, causing fatalities not only among those willing to fly, but also among "innocent" ground bystanders. It is, by nature, at least as international as the nuclear business. One can also argue than mankind could live easier without air travel than without energy supply.

From the point of view of the candid non-specialist that I am, what makes the air travel industry successful are the following fundamentals :

- Aircraft certification : a limited number of fully standardized planes, covering however a wide variety of size and range, are certified and authorized to fly the world around. We must commend NRC for having taken steps in that direction with the advance certification procedure, even though it is only valid in the USA.
- Industry rationalisation : very few manufacturers supply many airlines in all the world with series of those planes. In terms of number of reactor vendors we are well along the way in the nuclear area with the recent rash of mergers and acquisitions, AREVA being a conspicuous example. In terms of series of standardised plants, we have a long way to go, and the example of the French programme unfortunately remains unique to this day.
- International operator certification following standardised training. By the way, their operators are called "pilots". We may, with the project of World Nuclear University, witness the early premises of such a process.
- Well defined flying regulations, taking however into account site-dependant conditions for take-off and landing.
- Standard and compulsory maintenance procedures for the aircraft to keep their authorisation to fly.
- More recently, stringent measures of physical protection, including thorough and technically up-to-date screening of both passengers and their luggage. In most countries, there are also dedicated police corps to deal with these security aspects.

Behind this, you have international agreements, the FAA, controls and inspections, and lengthy lines at the security portals… but it works. Any certified crew can fly a properly maintained certified plane from airport A in country X to airport B in country Y, provided there is enough fuel, of course. And the countries overflown by this plane do not relinquish their national responsibility for safety of the air traffic over their territory.

By contrast, let's take the PWR : this technology originated in the United States where it was duly licensed, and was later transferred to many countries, among which Germany and France. In both countries, designs were adapted to fit national regulations, while the US models were themselves evolving. During the 90s, it took an inordinate amount of efforts to the French and German industry, with the help of the European Utilities, both Safety Authorities and their supporting experts, to converge towards an EPR licensable in both countries. And now, my guess is it would require another decade to get it certified by the NRC !

As long as we are not able to set up organisational measures similar to those of air travel, nuclear power will be impeded in its ability to really fulfil its international potential. This will, indeed, mean relinquishing parts of what is today considered as national responsibilities to some supranational body, yet to be invented. This goes much beyond the present missions and power of the IAEA, but the International Safety Convention is already a step in the right direction. And standard regulations must not only apply to nuclear plants but to all fuel cycle facilities, waste disposal, without forgetting the transportation.

As a matter of fact, the first items which have effectively been internationally standardised within the nuclear business are those which deal with transportation. The need was more urgent : packages, casks and containers travel, while power plants rarely do… Those which do are often located aboard military crafts and, as such, are subject to very specific regulations and limitations.

Non-proliferation

In terms of safety, nuclear power has nothing to envy to any other industry. My guess is, if an aircraft had as many defence-in-depth equipment as a power plant, it would be very safe indeed …because it would not be able to take-off. Just to point out that comparisons have their limits, but also to issue a warning : international safety regulations cannot simply be the "pancaking" of all the national requirements, otherwise nuclear plants will never fly !

Apart from safety, there are good reasons, however, why security measures are important in airports and around planes. Even before the September 11 attacks demonstrated new ways to misuse civilian aircrafts, plane were extensively used for smuggling, weapon and drug trafficking, etc. This is a specificity of any international travel. Nuclear technology has also its specificity, and it is the risk of proliferation. As we touch the main topic of our seminar, allow me to pay my respects to History.

Brief History

Year	Country	Proliferation	Nonproliferation
1945	USA	First A bomb	
1949	USSR	A bomb	
1952	United Kingdom USA	A bomb First H bomb	
1953	USSR USA	H bomb	 **Atoms for Peace** 12-8-53
1956	UN		Creation of the IAEA
1957	United Kingdom	H bomb	
1960	France	A bomb	
1963	USA/USSR/UK		Moscow Treaty (to limit tests)
1964	China	A bomb	
1967	China	H bomb	
1968	France	H bomb	 Non-Proliferation Treaty NPT
1974	India IAEA Exporters	A "Peaceful Test"	 "Trigger" list London Suppliers Group
1990	Iraq		Gulf War
1995	Ukraine, Belarus		Weapons returned to Russia Indefinite extension of NPT
1999	Pakistan	A bomb	
2002	North Korea	First exit from NPT	

The United States first tried to protect its military nuclear monopoly by refusing any transfer of civilian nuclear technology. When proliferation occurred in the USSR anyway, President

Eisenhower changed tack and allowed other countries access to reactor technology in exchange for their commitment to using the technology for civil applications only. We are celebrating this event today.

During the Cold War, the United Kingdom, then France, and lastly China, joined the Nuclear Weapon States.

In 1968, the Non-Proliferation Treaty, **NPT**, attempted to freeze the situation by recognizing 5 legitimate nuclear powers but no more. In exchange, the nuclear powers undertook to reduce their arsenal and give free rein to civil technology transfers. The International Atomic Energy Agency, **IAEA**, set up by the UN in Vienna in 1956, was entrusted with the task of overseeing the peaceful use of nuclear materials. Under IAEA control, technology transfer agreements rose rapidly, each exporter imposing on the recipient its own conditions for the use of the technologies, facilities, and materials exported.

In 1974, India, which had not signed the NPT, upset the apple cart by carrying out a "peaceful explosion", using plutonium produced in a heavy water reactor supplied by Canada. Exporting nations then agreed to regulate "sensitive" exports.

In 1991, a similar shock was felt with the discovery of the extensive clandestine nuclear program of Iraq, a country that had signed the NPT. As a result, the powers and inspection capabilities of the IAEA were reinforced (the so-called 93+2 program).

With the end of the Cold War and the disintegration of the USSR, the Russian Federation became sole inheritor of the former nation's military nuclear power status. Then Pakistan, India's rival since the 1948 partition, crossed the "nuclear Rubicon" in 1999. The last episode is taking place now in North Korea, the first country to denounce the NPT.

The important point, though, is that since 1974, proliferation has not spread like wildfire. Quite to the contrary, many countries which were on the "suspects" list have eventually joined the NPT as non-weapon states (Argentina, Brazil, South Africa, to name a few), and no new entrant has appeared (Israel, India and Pakistan, Iran and North Korea were already on the list). The voluntary bargain approach of Eisenhower did work, as did globally the NPT regime. *Despite Korean and Iranian developments*, the NPT, backed up by IAEA inspections, now forms the universally acknowledged basis for all nuclear commerce. It would be very irresponsible to throw the baby with the bath water.

Civilian nuclear industry and proliferation

Except for India, which cleverly played with the clauses imposed on it by Canada, no country opting for proliferation has done so by misappropriating materials or facilities covered by commitments to peaceful use and under IAEA control. Furthermore, fission cannot be "uninvented", and there will always remain the risk of a State or a large subnational group deciding to make nuclear weapons and to accept the political consequences.

Bearing that in mind, the real question is: does the development of nuclear energy for civilian applications increase *or reduce* the risks of nuclear weapons proliferation? This formulation may seem provocative, but the question should be asked in those terms and the answer is not necessarily simple nor straightforward.

Although possessing a civilian nuclear facility within its borders may give a State quicker access to the necessary fissile materials, a civilian nuclear industry also means international agreements and treaties, commitments not to misappropriate materials, and international inspections with highly sensitive and effective measuring devices. It makes it much more difficult to carry out a clandestine program.

And let us not forget that civilian nuclear energy *does already* contribute to nuclear disarmament by "demilitarizing" the fissile materials made superfluous at the end of the Cold War. Examples are the dilution of highly enriched uranium today, and the recycling of military plutonium as MOX fuel, tomorrow.

I have already expressed my view that non-proliferation will not be not prevented through technological choices for the future nuclear power systems, though technology can achieve a lot for ensuring detection and exposure of any misbehavior. The recent MIT study which advocates sticking to the once-thru LWR cycle is just a revival of the old policy that former President Carter tried to impose upon the world through the INFCE exercise in 1977, and it is bound to be exactly as inefficient. The need for long term sustainability will eventually require recycling and some form of breeding. And if you believe in technological "fixes", what is the best solution : regional fuel cycle centers which minimize the number of sensitive facilities and guarantee their international control and safeguard, or closed reactor and fuel cycle collocated systems, which minimize transports of concentrated fissile materials ? It can easily be argued both ways.

But I will end with what constitutes for me the most important consideration. Nuclear proliferation is just one form of arm race among others. One of the root causes of the arms race is insecurity. The risks of tension on the energy market are sources of insecurity. This needs hardly to be emphasized in the wake of the second Gulf War. By allowing a partial diversification of a market dominated by hydrocarbons, the extension of nuclear power would contribute to the world's geopolitical stability and, hopefully, reduce motives for proliferation.

Conclusion

The world needs nuclear power. Meeting the increasing needs for energy while reducing the GHG emission is a formidable challenge if we can make use of all the sources available, it would be an impossible task if we were to forego one of them. The vision expressed in the Atoms for Peace address is possible to fulfill : let's endeavor to do it.